A Paint Catechism For Paint Men

Second Edition—Revised and Extended

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Comprising terse practical definitions of paint materials and answers to the questions met in the sale and use of paints

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A Paint Catechism

FOR

Paint Men

By

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PREFACE TO SECOND EDITION

The first edition of this little compilation met with a reception that proved its acceptability. The first issue of twenty thousand copies was exhausted almost before it was off the press, and rapidly succeeding reprints have been taken, until the total number of the first edition amounts to 250,000 copies. As orders are still being received, it has become necessary to replenish the supply.

Four years have elapsed since the booklet was written, and in the meanwhile the paint industry has rapidly advanced. New materials have been made available, new methods of using old materials have been discovered and field tests have given us more definite information regarding the comparative value of paint combinations.

Among the new technical discoveries is the revolutionary work on corrosion and the resultant theory of inhibition developed by Cushman, Walker and others, whose investigations have profoundly affected the practice of manufacturers in this field.

Among the new materials tentatively or definitely in use is soya bean oil; and among the old materials for which new or more definite uses have been found, are lithopone, menhaden oil and benzole.

It has seemed desirable that these technical advances should be included in a new edition of the "Paint Catechism." These additions, therefore, and some desirable modifications in the remaining text, constitute the present revision.

It is hoped that this new and revised edition will prove as acceptable as the old edition—more could not be expected.

Phila., Pa., Oct. 1, 1911.

INTRODUCTION TO FIRST EDITION.

The compiler of the following questions and answers claims no originality in subject or substance.

It has seemed desirable that sellers of paint should have available, in compact and convenient form, the technical knowledge of their specialty which has been accumulating during the past half century. This "Paint Catechism" is, therefore, a compendium of such information, gathered from many sources, and condensed for quick reference.

Where actual quotation has been made, the authority is given; but those definitions for which no authority is cited, while in no case original except as to language, must be credited to the writings of paint chemists and technical authorities in general.

It is hoped that the booklet may prove a real convenience for those for whose use it is intended.

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1. What is paint?

"Any liquid or semi-liquid substance applied to any metallic, wooden or other surface to protect it from corrosion or decay, or to give color or gloss, or all of these qualities, to it." —*Wood.* More properly speaking, paint is a mixture of opaque or semi-opaque substances (pigments) with liquids, capable of application to surfaces by means of a brush or a painting machine, or by dipping, and of forming an adherent coating thereon.

2. What is the purpose of paint?

To protect or to beautify surfaces, or to perform both offices. Paint is also valuable as a sanitary agent.

3. What is house paint?

House paint is paint designed to preserve and to beautify the surfaces of materials used in the construction of buildings.

4. What is the best house paint?

That paint which most completely fulfills the offices named.

5. What are the materials used in manufacturing house paints?

Pigments, drying oils, volatile oils or thinners, driers or "Japans" and varnishes.

6. How may these pigments be divided?

Into white bases, inert reinforcing pigments, natural earth colors, chemical colors, pigment lakes, etc.

7. Name the white bases.

Oxide of zinc, basic carbonate of lead (or corroded white lead), basic oxy-sulphate of lead (or sublimed white lead), leaded zincs, and lithopone; together with certain inert or reinforcing pigments (described herein under their proper titles.)

8. What is oxide of zinc?

Oxide of zinc is a combination of one atom of metallic zinc with one atom of oxygen. It is produced by two methods, one known as the French and the other as the American process. In the French process, metallic zinc is burned in a current of air and the product of combustion, oxide of zinc, is collected in closed chambers. In the American process, ores of zinc mixed with finely powdered anthracite are burned in a closed furnace, having perforated grate bars, and the resultant oxide of zinc, after being blown through a series of cooling flues, is collected in fabric bags.

9. What are the characteristics of oxide of zinc?

In texture it is the finest of all white pigments and in color the whitest. A pound of dry oxide of zinc occupies about 50.77 cubic inches, while a pound of corroded white lead in the same condition occupies only 14.69 cubic inches. In consequence of its extreme fineness it requires more oil than any other white pigment to fit it for use with a brush. In one hundred pounds of zinc oxide paint ready for use, there are about 46 lbs. of oil and 54 lbs. of pigment, while the proportions in a corroded white lead paint of similar consistency are about 76 lbs. of pigment to 34 lbs. of oil. Oxide of zinc is unaffected in color by any gases present in the atmosphere, has no effect upon any pig-

ment with which it may be mixed, and is non-poisonous.

10. What is corroded white lead?

It is a compound of metallic lead with carbonic acid gas, oxygen and the elements of water. It is usually described as a combination of hydrated lead oxide with lead carbonate, in the proportion of about two parts of the latter to one part of the former, though the variations from these proportions are extreme. Corroded white lead having the theoretically correct composition is very opaque and dense, and though not so white as oxide of zinc, is quite white. An excess of either chemical constituent impairs its good qualities and its color. It is prepared in this country by four processes, known as the "old Dutch" or "stack" process, the cylinder or "quick" process, an American modification of the Dahl process, and a "mild" acidless process.

11. What is old Dutch Process White Lead?

The process generally known by that name is an English modification of the original Dutch process. The process as used in this country is in outline, as follows:

Metallic lead is melted and cast into perforated disks, called buckles, about six inches in diameter, which are put into pots containing, in wells, about one pint of dilute acetic acid (vinegar). These are placed in rooms holding several layers, or tiers, 600 to 1,000 pots each. The pots are covered with boards and layers of tan-bark, placed between each tier. The rooms, technically called "stacks," are kept closed from three to four months. During this period the heat and the carbonic acid gas generated by fermentation of the tan, together with the acid vapors, combine to corrode the lead more or less completely, into a white flaky substance (basic lead carbonate).

This, after it is crushed, screened, floated, ground in water and dried, forms the white lead of commerce, and is either sold in the dry state to paint and color manufacturers, or ground in linseed oil and sold for general painting purposes.

White lead thus produced is a compound of lead hydroxide and lead carbonate, often retaining a residue of acetic acid and more or less water. It is somewhat variable in composition, nearly every sample analyzed showing different proportions of the constituent components. Thus in four analyses reported by Prof. Hurst the proportion of carbonate ranged from 63.35 per cent. to 72.15 per cent; and that of the hydroxide from 25.19 to 36.14; and that of the moisture,from 0.42 to nothing. Prof. Church gives the ideal proportions as 70 per cent. of the carbonate to 30 per cent. of the hydrate, but this exact proportion is very rarely attained in practice. Fifteen different American brands of pure old Dutch Process White Lead recently analyzed by Dr. P. H. Sadtler varied from 60.70 to 81.89 lead carbonate and 17.03 to 38.60 lead hydroxide.

The samples analyzed were commercial leads, extracted and dried. Leads in oil, especially when mixed without drying, as in the pulp process, will generally show a higher percentage of moisture, while acetic acid, tan bark and uncorroded particles of lead, left by imperfect grinding and washing, are not rare. Church reports as high as eleven per cent. of lead acetate in flake white. The color is also somewhat variable.

White lead combines readily with linseed oil, works easily under the brush, and increases the drying properties of linseed oil.

12. What is Cylinder or "Quick Process" White Lead?

In this process the melted lead is blown into fine granules by means of a jet of superheated steam. This powdered lead is charged into large, slowly revolving wooden cylinders or drums, moistened with dilute acetic acid and subjected during several days to the action of air and carbonic acid derived from burning coke. The subsequent procedure resembles closely the methods of the old Dutch process.

The white lead produced is generally finer, whiter and more uniform than Dutch process white lead. Chemically it resembles the latter very closely, and is essentially the same;

but, owing to its greater subdivision, requires more oil to prepare it for use.

13. What is Dahl Process White Lead?

In the modified Dahl process the metallic lead is first reduced to a fluffy or feathery condition. It is then placed in stationary tanks and by the action of dilute acetic acid, converted into a basic acetate of lead. The passage of a stream of carbonic acid gas through this solution precipitates the lead in the form of the basic carbonate (white lead). Washing, drying and grinding follow, as in other processes. The lead produced in this manner is exceptionally white, fine and uniform, and the particles are amorphous and not crystalline as in other precipitation processes. Owing to its fineness it requires more oil to grind than other leads, exceeding "quick process" lead in this respect as the latter exceeds "stack" lead. The obscuring power or opacity of precipitated leads is generally lower than that of corroded leads.

14. What is "Mild Process" White Lead?

"The unique feature in this new process is that neither acid nor alkali is used—the conversion from pig lead to the basic carbonate being effected entirely by the successive action of moisture, air and carbon-dioxide gas. To this must be added the perfect control which the operator has in all stages of its manufacture.

"In brief outline the proceeding is as follows: Pig lead is melted by means of a specially designed machine and subjected to a blast of superheated steam, which reduces the metal to its finest possible state of subdivision. This process partly hydrates and oxidizes the comminuted lead which passes thence into cylinders fitted with agitators, and containing water, through which a current of air is passed. The sub-hydroxide of lead is here further oxidized into lead hydroxide, which is then treated in other cylinders containing water with a stream of purified carbon-dioxide gas, which converts it into basic white lead, after which the completed product goes to specially designed drying beds."

15. What are the characteristics of "Mild Process" White Lead?

"Absolute uniformity; freedom from acids, alkalies and all impurities; extreme fineness, crystalline matter being entirely absent; whiteness and normal composition."

16. What are the characteristics of Basic Carbonate White Lead?

"It is scarcely necessary to point out that, as white lead is made by many processes, it must necessarily vary in composition; indeed, the white leads yielded by the same process do not always have the same composition."—*Hurst.*

White lead is the most opaque of white pigments, a fact due largely to the small proportion of liquid required to reduce it to painting consistency; its spreading power, however, is correspondingly small. The lead hydrate contained in it unites, under certain conditions, with the acids of linseed oil to form a lead soap, which, while improving its brushing qualities, reduces its durability. It changes into the black sulphide of lead on exposure to sulphuretted hydrogen gas, and as this gas is almost universally present in the atmosphere, pure white lead seldom retains its original color, though further oxidation yields lead sulphate, which is, again, white. While a useful and valuable pigment on account of its opacity and working qualities, it is subject to somewhat rapid disintegration. The durability of a good white lead paint may be about three years, but in the meanwhile the paint will have disintegrated on the surface and begun to wear off in the form of a fine powder ("chalking") or to come away in minute flakes ("scaling"). The powder and the scales, as well as the dust arising therefrom, are poisonous.

Another technical defect of white lead, as generally used, is that it is sold in the form of a very thick paste, containing only about ten per cent. of oil. The purchaser adds the necessary liquids to fit it for use, stirring the mixture with a paddle. Uniform consistency is not obtainable in this way, and the paint produced is inferior to that produced by means of mechanical mixers.

17. What is Pulp Ground White Lead?

As explained in connection with the manufacturing processes, white lead in its final stage, before drying, is floated in water and allowed to settle. When the excess water has been decanted from the settling tanks, the residue is known as pulp lead. If this paste be intimately mixed with linseed oil, the oil will gradually displace the water, which can then be drawn off. Pulp Ground White Lead is pulp white lead, which has been mechanically mixed with oil, without previous drying; the mechanical process facilitating the displacement of the water by the oil. The completeness of this displacement depends upon the duration of the process.

18. What is Sublimed White Lead or Oxy-sulphate of Lead?

"This product is so named because it is obtained by a sublimation process (from lead sulphide ores by a process analagous to that used to produce American zinc oxide). The product is obtained directly as a very fine, impalpable white powder, without grinding. Chemically it is different from ordinary white lead, being apparently a basic sulphate of lead and * * * has approximately the following constitution:

Lead sulphate	75	per cent.
Lead oxide	20	" "
Zinc oxide	 5	" "

"It exceeds in the fineness of the particles the ordinary grades of white lead, and is at least equal to them in whiteness, body, covering power and wearing qualities. It differs from ordinary white leads in being non-poisonous, and resists the blackening action of the sulphur compounds of sewer gas and of fuel gas to a much greater degree."—*Ladd.*

"The lead sulphate and lead oxide are chemically combined in sublimed white lead, forming the true basic sulphate. This chemical combination of the sulphate and oxide into the basic compound explains the high degree of opacity which this pigment possesses. Its physical structure is entirely different from the ordinary lead sulphate, which has no pigment value. The

zinc oxide present is caused by the presence of a small amount of zinc in the raw material used in its manufacture."—*Hughes.*

19. What are the Characteristics of Sublimed White Lead?

"Like all pigments produced by sublimation process, sublimed lead possesses in its ultimate particles a fineness far superior to that of pigments otherwise produced. On account of the extreme fineness of its particles it does not settle out of liquid mixtures. Being an oxysulphate, it resists the discoloring action of hydrogen sulphide and other harmful gases in the atmosphere longer than does any other lead pigment. It is uniform in composition, is non-poisonous, and has no destructive effect on the paint vehicle. Expert paint manufacturers early recognized these characteristics and the paint manufacturing industry consumes practically the entire production." When used alone, it "chalks" rather more freely than corroded white lead.

20. What is Sublimed Blue Lead?

A sublimation product closely allied to sublimed white lead, the process being similar, of somewhat different composition and color. A characteristic analysis follows:

	Per cent.
Lead sulphate	52.92
Lead oxide	37.48
Carbon	2.25
Zinc oxide	2 to 4
Lead sulphite	1 to 1½

21. What are the Characteristics of Sublimed Blue Lead?

Being a "fume" product, its spreading power in oil is high (more than twice that of red lead). Its lead content is as high as in other lead pigments. It remains well in suspension and brushes well, having better tooth than most lead pigments. It is practically inert in linseed oil and is not affected by atmospheric gases. The official tests at Atlantic City place it high among the class of rust-inhibitors.

*** 22. What is Zinc-Lead?**

"This pigment which has made its appearance within the last few years (fifteen or twenty) and which is practically unknown to the general public, is prepared from low grade zinc-lead ores which also usually carry small quantities of copper, silver and gold, the latter metals being exhausted after the removal of the zinc and lead. As prepared, it is apparently a molecular combination of zinc oxide, lead sulphate and small proportions of lead carbonate and oxide. The combination, if it may be so termed, being effected at a high temperature, while the metals are in the form of vapor, the union is far more intimate than would be obtained by grinding together the separate component pigments.

"In physical appearance the zinc-lead whites closely resemble a good grade of zinc oxide, but their specific gravity is higher and their density greater. This difference becomes more noticeable on grinding with oil, the proportion of oil taken up being much nearer the figure for Dutch process white lead than to that for zinc oxide. The density or obscuring power of the resultant paint places it in the lead rather than the zinc class. The chief objections made to it are that it is not always uniform in composition or color. An average of a large number of anlayses gives it the following composition:

Lead sulphate	48.10
Lead carbonate	0.50
Lead oxide	0.60
Zinc oxide	50.50
Zinc sulphate	0.30"

—*Ladd.*

23. What are the Characteristics of Zinc-Lead-White?

It is very fine, amorphous and uniform in the size of its particles; remains well in suspension; has a high spreading power; is durable and has little or no effect on any color with which it may be combined.

*Note.—This special product is not at present available in the market; but leaded zincs approximating it in composition are obtainable.

24. What is Lithopone?

Lithopone is essentially a combination of precipitated zinc sulphide and barium sulphate (blanc fixe or "permanent white"). It is produced by the simultaneous reaction on one another of a solution of zinc sulphate and barium sulphide, the two chemicals in solution being in the correct combining proportions. The two substitution products being formed and precipitated simultaneously, the union is very intimate. The process is often completed by dropping suddenly in cold water while hot. The product is very fine, white, and amorphous, and if properly made has excellent body and most valuable properties as a pigment, though most varieties of it are inadmissible in connection with lead pigments, on account of the susceptibility of the latter to darkening from sulphide combinations. For this reason it should not be used with oils containing a lead dryer. It also has the peculiar property of darkening in sunlight and recovering its color in the dark; and on exterior exposure it "chalks" very freely. It finds extensive use in the manufacture of "flat," washable wall finishes, in enamel paints and in linoleum and shade-cloth manufacture.

"When the material first appeared we examined it and it seemed to be the thing we were hunting for, something that was free from the objections to white lead and zinc white. * * * Experiments with it seem to indicate that it has covering power, body, working qualities and chemical inertness."—*Dudley.*

25. What are the Characteristics of Lithopone?

Fineness, whiteness, body and opacity. "As an interior white, a first coat white, a ready-mixed flat paint for a surface, or as a pigment in the lighter shades for floor paints, lithopone cannot be excelled for its body durability, hardness, fineness of grain, and ease of application. * * * The paint chemist should be permitted to decide when its value is the greatest. As a marine paint, either as a first coat or for making neutral whites where other whites would be necessary, it is found to outlast both zinc oxide and lead carbonate."—*Toch.*

*** 26. What are Leaded Zincs?**

Oxides of zinc produced from ores of zinc (mainly carbonates and silicates) which contain a certain proportion of lead sulphide ores. In the process of manufacture the lead sulphide is transformed into lead sulphate (sublimed white lead) and intimately united with the zinc oxide. They are made with definite percentages of lead sulphate, ranging from about sixteen to about thirty per cent., according to the purposes for which they are to be used. They resemble zinc-lead in composition, except that the proportion of the lead component is lower and the color generally whiter.

27. What are the Characteristics of Leaded Zincs?

In fineness they are similar to other zinc oxides, in whiteness slightly inferior. Their opacity is measurably greater on account of the contained lead sulphate. All western zincs contain some lead. "The zinc oxides made from western ores are slightly more permanent than those made from New Jersey ores, and as paint materials they possess the advantage of containing a larger quantity of lead sulphate." —*Toch.*

28. What is the effect of a small percentage of zinc sulphate in paint?

"Nearly all zincs contain a small percentage of zinc sulphate. Much unnecessary trouble has been caused by the criticism against zinc sulphate. Where a paint contains moisture or where water is added in a very small amount to a heavy paint in order to prevent it from settling and not more than one per cent. of actual water (not water of hydration) is contained in the paint, zinc sulphate forms an excellent drier, particularly where it is desirable to make shades which contain lamp black. The outcry against zinc sulphate is unwarranted because as much as five per cent. is used in making a patent drier.

*Note.—Oxides containing less than 16 per cent. of lead sulphate are classified as zinc oxides; from 16 per cent. to 30 per cent. as leaded zincs; from 30 per cent. upwards, as zinc-leads.

The amount of zinc sulphate, however, in most of the dry zinc pigments, decreases with age. * * * In the enamel paints, the presence of zinc sulphate is not a detriment, and in floor paints it might be considered as a slight advantage, for it aids in the drying and hardening."
—*Toch.*

29. What is an "inert or reinforcing pigment?"

An inert pigment, properly speaking, is a chemically stable solid substance used as a component of paint—one which neither acts upon nor is acted upon by any other constituent. In this sense lamp black, graphite, carbon black, lead sulphate, smalts, etc., are inert pigments. Commonly, however, the term is applied to certain white or colorless substances added to white or colored paints for various technical purposes; especially to form the solid base on which staining colors are to be precipitated (as in the chemical lakes), to decrease the preponderance of chemically active pigments in the paint film (as where barytes or silica is added to basic carbonate white lead), to limit the excessive spreading power of a paint and thus to increase the thickness of the paint film, and to give it "tooth" (as where barytes or silica is added to white paint bases).

The word "inert" has come to be used in connection with these pigments, because speaking generally and in a broad sense, they have the great advantage of being chemically stable or "inert" and not affecting color nor destroying the life of the vehicle. "A more practical definition of the inert reinforcing pigments would be to state that they comprise a class of materials, each one of which possesses all of the valuable qualities of the true pigments with one or more exceptions; as for instance, an inert pigment may possess covering power, proper performance in the vehicle, absolute chemical stability or inertness, the maintenance of tone while reducing the strength of color, and yet while being deficient in great obscuring power or opacity as compared with white lead, for instance, this one drawback of inferior

opacity will be more than offset by the peculiar qualities and advantages to the resulting paint which are entirely lacking in white lead and cannot be procured therefrom. Therefore the manufacturer can obtain all the necessary obscuring power by a proper proportion of true pigments and gain the peculiar and equally important advantages from the use in addition of such a reinforcing pigment."

30. Which are the Inert Pigments in Common Use?

Barium sulphate (barytes, blanc fixe, permanent white), silica (silex, silicious earth), magnesium silicate (asbestus, asbestine, pulp, talc), alumina (china clay, precipitated alumina, feldspar, kaolin) calcium sulphate (gypsum, terra alba) calcium carbonate (white mineral primer, Paris white, whiting, etc., etc.)

31. What is Barium Sulphate, Barytes, Blanc Fixe or Permanent White?

Barium sulphate comes into paint manufacture under several forms dependent upon the method of preparation. Chemically, it is a compound of an atom of the metal barium with one molecule of sulphuric acid, the former replacing the two atoms of hydrogen normally existing in the latter. It is found as a natural product in many parts of the world, and is a usual accompaniment of lead and zinc ores. The principal sources of supply in this country are in Missouri, Arkansas, Tennessee, N. Carolina and Virginia.

The process of preparation consists essentially in grinding, removing impurities in an acid bath, and thorough washing. The finer grades are further separated by water floating.

Precipitated barium sulphate, commonly known as blanc fixe or "permanent white," is produced by precipitation of a soluble salt of barium from solution by means of a soluble sulphate. The barium sulphate is thrown down as an impalpable amorphous powder. The method is similar to that for lithopone, except that the substitution product here remains in solution.

In the preparation of several of the more permanent lakes, barium sulphate is thus precipitated simultaneously with the "striking" of the color, the union of base and "stainer" being thus made more intimate.

32. What are the Characteristics of Barium Sulphate?

Its chief characteristic is extreme chemical stability. It neither reacts nor forms a chemical combination with any other material used in paint making, and remains absolutely unaffected by the elements or by any gases or vapors found in the atmosphere. It is, in the full meaning of the term, inert. It is also practically colorless when mixed with oil, hence has no modifying effect upon colors mixed with it. It is, therefore, an excellent medium for diluting highly colored pigments without modifying their tone; for diluting chemically active pigments and thus prolonging the life of the oil in a paint film; for modifying the spreading power of many finely divided pigments, and for increasing the thickness of the individual paint film. It has been long used for admixture with lead and zinc in white paints, and this addition is held by practically all competent authorities to increase the durability of such paints.

33. What is Silica (or Silex)?

It is an oxide of the metal silicon, consisting of one atom of the latter with two atoms of oxygen. It is very abundant in the earth's surface and exists in many forms, of which quartz, rock crystal, amethyst, quartz-sand and flint are the most familiar.

For use in paint manufacture it is prepared in several ways. By one method the transparent quartz rock is first disintegrated by heating and dropping into cold water, followed by grinding and bolting or water floating. In another fine quartz sand is similarly treated. Still another source of supply is the microscopic skeletons of diatoms found in the dry beds of geologic oceans. This grade is known as silicious earth, and requires only cleansing and bolting to fit it for use.

34. What are the Characteristics of Silica?

Hardness, inertness and co'orlessness. In oil, it has even less color than barytes. It is used for practically the same purposes as the latter, and very widely as the mineral base of paste wood fillers, for which purpose it is generally held to be unequalled. In paints, it is held by some paint manufacturers to be superior to other inert pigments because of what is termed its "tooth," meaning the firmness with which it takes hold on a wood surface and adheres to other coats of paint.

35. What is Magnesium Silicate?

A complex combination of silicic acid with the metal magnesium and water of hydration. Serpentine, asbestus, jade and chrysolite are some of the forms under which it appears in nature. These forms are of great variety and shade into one another. The forms used in paints are generally modifications of talc and asbestus. For such use it is purified and ground to impalpable fineness.

36. What are the Characteristics of Magnesium Silicate?

Inertness, fineness, unctuosity, lightness of gravity and a sort of physical 'fluffiness," which tends admirably to keep it in suspension. In its properties as an inert pigment it resembles those already considered, but physically it is very different. It is much softer, makes a very smooth paint and is held by those who use it to prevent "settling in the can" to a greater extent than the other pigments of this class. The hair-like structure of the asbestiform varieties is also held to be mechanically advantageous.

37. What is Alumina?

An oxide of the metal aluminum, consisting of two atoms of the latter combined with three atoms of oxygen. In this form it occurs in nature as corundum, emery, ruby, sapphire, etc. Alum, which is a sulphate of alumina, under certain conditions precipitates a trihydrate of aluminum, which is a powerful absorbent of

organic dyes. This fact is taken advantage of in dyeing fabrics and in the preparation of several of the lakes.

The silicate of aluminum—China clay, kaolin and feldspar—is usually, though incorrectly, called "alumina" and hence is described here under this heading. These substances are complex hydrated silicates of alumina, (kaolin or China clay being feldspar which has undergone decomposition by age-long action of the elements). The former is taken from the earth, washed and floated. The latter is ground and bolted or floated to prepare it for use.

38. What are the Characteristics of Silicate of Alumina?

Inertness, practical absence of color—though in this the clays are inferior to barytes and silica, while feldspar is about the same—impalpable fineness in the case of kaolin, appreciable "tooth" in the case of feldspar. Otherwise the material is comparable to the silicate of magnesium in its properties. An important eastern railway company has for years specified China clay as a component of its station paints.

39. What is Calcium Sulphate?

The hydrated sulphate of the metal calcium, consisting of one atom of the latter combined with one molecule of sulphuric acid and two molecules of water of crystallization. When a part of this water is driven off by high heat the substance becomes "plaster of Paris," which again hardens on absorbing water. A similar phenomenon is familiar in Portland cement. Calcium sulphate in its native form is known as gypsum,—when transparent, as selenite.

For use in paints it is carefully ground, so as to avoid driving off the water of crystallization, and bolted.

The authorities of the Pennsylvania Railroad and some other lines prefer calcium sulphate to other inert pigments—on economic grounds alone, however—and require large percentages of it in their specification paints.

40. What are the Characteristics of Calcium Sulphate?

Inertness, medium softness, colorlessness, and ease of manipulation. It is soluble in 500 parts of water; that is, one pound will be dissolved by about 63 gallons of water; and this property impairs its value. If the hydration be complete, gypsum is fairly efficient and for some purposes would appear to be preferable. Dr. Dudley, of the Pennsylvania R. R., as above indicated, gave it full preference.

41. What is Calcium Carbonate?

A combination of the metal calcium with carbonic acid in the proportion of one molecule of the former with one of the latter. It is familiar in nature as marble, chalk (from which whiting is produced by grinding, washing and floating), Mexican onyx, crystalline calcite, etc. For use in paint it comes in the form of the finer grades of whiting, Paris white (both made from floated chalk), mineral primer (made by grinding and bolting a natural dolomite), etc.

42. What are the Characteristics of Calcium Carbonate?

Each of these forms of calcium carbonate has its own peculiarities. The finer qualities of chalk produced from ancient shell deposits, when finely washed and floated, produce a product known as "Paris white" or "bolted whiting." This is practically amorphous and is extremely fine, tends to hold pigments in suspension, neutralizes any free mineral acid in the oil or pigments (although inert to neutral linseed oil) spreads well and is useful with heavy oxide pigments. Another type of calcium carbonate is white mineral primer. This has a definite structure, but is ground extremely fine and floated. This structure gives it a certain "tooth" which makes it an excellent filler and shortener for retarding the excessive spread of zinc oxide. Both of these forms of calcium carbonate are found useful in many types of paint where advantage is taken of their physical as well as their chemical characteristics. Thus any residue of sulphuric acid remaining

in linseed oil from the refining process, any traces of mineral acid remaining from bleaching barytes, any excess of sulphuric acid in the iron oxides, can be most safely and effectually neutralized by an addition of calcium carbonate to the paint. For this purpose the Pennsylvania R. R. specifications require the addition of a small percentage of this ingredient.

It is worthy of note that the old-time putty, which was made of linseed oil and calcium carbonate alone, has been known to endure without apparent deterioration, for half a century.

43. What are Natural Earth Colors?

Colored compounds found as deposits in the earth and utilized as pigments, either in their natural state after grinding and purification, or after further treatment, such as oxidation by burning, calcination, etc. The principal varieties are the mineral browns (Prince's mineral), ochres, umbers, siennas, natural iron oxides, mineral black and a few allied substances. Of these, Prince's mineral is a natural iron carbonate which is changed to the sesqui-oxide by furnacing in a current of air; raw umber is a similar natural iron oxide containing manganese and burnt umber the same, changed by heat. Raw sienna is an allied mineral and burnt sienna the same further oxidized by calcining.

Similar to these are the so-called oxides produced by grinding the natural iron oxides (haematites) from various localities. They range in color from a warm brown to a brilliant scarlet, dependent upon the composition of the original mineral and the degree of oxidation.

Similar highly colored products are produced by driving off the sulphuric acid and water from sulphate of iron (green vitriol). Venetian red, an allied product, is produced by precipitating the iron oxide of green vitriol from solution with lime water and afterward oxidizing in a furnace. The resultant product is a close combination of iron oxide with calcium sulphate. Venetian reds of similar character are also produced by grinding high-grade iron oxide with inert bases, such as calcium sulphate.

Ochres are hydrated iron oxides permeating a clay base. They are produced by age-long percolation of water through a body of iron ore into adjacent veins or beds of clay. They differ widely in color, tone and composition.

44. What are Chemical Colors?

Chemical colors are pigments produced by chemical action of one substance (usually in solution) upon another, resulting in the precipitation of a colored compound. Following are the principal chemical colors in common use: The various Prussian or cyanide blues (Chinese blue, Antwerp blue, etc.,), made by precipitation from the ferro-cyanide or ferri-cyanide of potassium by a soluble salt of iron. The chrome or chromate yellows are made by precipitating a soluble lead salt with a soluble chromate, the resultant product being a lead chromate. The various shades (light, medium, deep, orange, etc.,) are produced by precipitating with the chromate some modifying substance like lead sulphate or barium sulphate. There is also a very permanent zinc chrome (largely used in "inhibitive" paints for structural steel) in which the lead base is replaced by zinc.

Chrome or chromate greens are combinations of a specially prepared Prussian blue with chrome yellow, usually precipitated together and modified in the darker neutral shades by the type of chromate used. These greens in their pure state are unsatisfactory as to permanence and color, hence it is practically the universal custom to grind with them some inert protective pigment,—barium sulphate preferably —which diffuses and reduces the pigment without materially impairing its color or opacity. A high-grade of commercially pure green, therefore, usually contains about 75 per cent. of barytes. These greens should never be used with a white base containing carbonate of lead, as the Prussian blue content will be bleached by it in the can. Oxide of zinc, sublimed white lead, or a leaded zinc should be used as the white base. Chromium oxide, the original "chrome green," is now but little used on

account of its high cost. Where great permanence is required, as on railroad signals and the starboard light boxes of vessels, it is still used to a limited extent.

Ultramarine and cobalt blue, English or Chinese vermilion, red lead and orange mineral, may also, in a certain sense, be termed chemical colors, in that they are the products of chemical transformation. The two blues are produced by a special method of fusing together the components of lapis lazuli (the original ultramarine). Neither of these colors should be used with any other pigment or substance containing lead. White lead, chrome yellows, chrome greens and even oils containing lead driers are therefore debarred. Oxy-sulphate of lead (sublimed white lead) does not act so strongly as the carbonate in discoloring the blue, but is thought to act slightly. The preferable white bases for these colors are oxide of zinc or sublimed lead, with or without the addition of inert pigments.

There are two true cobalt blues, of which one is familiar as "smalts." The other is a compound oxide of cobalt and alumina. It is more familiar as an artist's color than as a pigment for house paints. The quicksilver vermilions are a sulphide of mercury, produced either by sublimation or by a precipitation process. Their color is apparently due to the form of the particles, and gradually changes, on exposure, to the natural brown or black of normal sulphide of mercury. They have been largely replaced by the so-called American vermilions and vermilionettes, the latter being really a form of lake and will be described under that heading.

American vermilion, sometimes designated as Chinese red, Persian scarlet, scarlet chrome, etc., was for many years in great demand, owing to its permanency, but as it loses its brilliancy by the breaking of its crystals when milled, it is now largely replaced by the aniline scarlets, which are classed among the fatest of the vermilionettes. In composition it is a basic chromate of lead, requiring special treatment to develop its color. (It is an excellent "inhibitor" or corrosion on steel surfaces.)

Red lead and orange mineral, as well as litharge, are oxides of lead. The first-named is produced by further oxidation of litharge at a low heat in an open furnace. Orange mineral is similarly produced by oxidation from the carbonate of lead instead of pig lead, and is therefore amorphous in structure and not crystalline. This makes it much easier to hold in suspension, while its color is lighter and more brilliant. These lead oxides form a cement with linseed oil and tend to harden in the can. Freshly mixed, they form an excellent protective coating for metal surfaces, but in time they produce "livery" paint. The addition of certain substances in small percentages delays this action. Fine grinding impairs their color.

45. What are Color Lakes?

A color or pigment lake is a pigment produced by the combination of a dye with a mineral base.

The varieties are exceedingly numerous. The number of such pigments among artists', lithographers' and carriage colors is, however, much larger than among house painting materials, since many of the lakes are transparent or translucent.

Some of the lakes are formed by simultaneous precipitation of the mineral base from solution with the coloring matter. The preferred base in such cases is usually alumina or barium sulphate.

The "para" reds (paranitraualine lakes) which have come into extensive use on account of their beauty, durability and body, are more brilliant and more permanent than quicksilver vermilion. Neither class of reds can be used with a white lead base without destroying the color.

46. What are the Carbon Blacks?

The carbon blacks are practically pure carbon. They comprise lamp black, a specially prepared soot from oil lamps; gas blacks (commonly known as "carbon blacks") from natural gas; and graphite, a natural product, now also produced artificially by means of the electrical furnace.

Bone-black, ivory black (a fine bone-black), drop black, vine black, etc., also come in this category. These, being produced by carbonizing animal and vegetable substances, contain proportions of inert mineral salts and are accordingly modified in tone.

47. What are the Characteristics of the Carbon Blacks?

With the exception of those named in the last paragraph, they are practically pure carbons. They are, therefore, chemically inert. Lamp blacks and gas blacks are amorphous, the particles are extremely fine and their specific gravity low; consequently, they require a surprising preponderance of liquid to fit them for use. Their covering capacity in proportion to weight is enormous and their durability is a striking example of the durability of inert pigments in general when used in painting. Their tinting power is great. They are seldom used alone as pure color, it being deemed technically advisable to grind with them such a proportion of colorless inert pigment as will measurably increase the thickness of the paint film without preceptibly impairing its opacity.

Lamp black lettering on old signs has been frequently known to stand out in relief after the wood surrounding it has been deeply worn away by the elements.

Graphite, among the carbon pigments, stands apart, its unctuous quality, familiar in stove-polish and lead pencils, distinguishing it. It comes in two forms—flake and amorphous. It is as durable as the other carbons and, like them, is frequently ground with silica or other colorless, inert pigments. Its chief use is in protective paints.

The remaining carbon blacks are used principally as tinting colors only.

48. What are the Drying Oils?

Linseed oil, poppy seed oil, nut oil, China wood oil, sunflower seed oil and menhaden or "fish" oil. The first named is very extensively used, the second two in artists' colors and some special paints where extreme whiteness is essential, the fourth is coming into favor for certain

lines of varnish. The fifth has been used in this country experimentally only. The last named is coming very extensively into use for special purposes.

To this list should be added certain semi-drying oils, such as corn oil, cotton-seed oil and soya bean oil.

49. What are the Characteristics of a Drying Oil?

Drying oils have the peculiar property of absorbing oxygen and forming a tough elastic substance. They harden, (with the exception of China wood oil, which seems to "set" simultaneously throughout, like cement) from the surface inward. Certain metallic oxides and salts when incorporated with these oils by heat or otherwise, by acting apparently as catalytic carriers of oxygen, hasten the drying process. On exposure the hardening progresses slowly until the material finally crumbles and disintegrates. The added metallic salts, etc., are known as "driers," the oil in which such driers have been incorporated as "drying oils" and if incorporated by heat, as "boiled oils." A strongly concentrated drying oil thinned with a volatile oil (turpentine, benzine, etc.) is also known as "drier," and sometimes, especially if a gum or resin be added to it, as a "Japan drier."

50. Why are Drying Oils used in Paint Manufacture?

First, to give to the paint the necessary fluidity; secondly, to insure the uniform distribution of pigment on the surface; thirdly, to form a firmly adherent and coherent film of the proper character; and lastly, to produce in the paint the desired lustre.

51. Why is Linseed Oil usually preferred for this use?

First, because it is the most abundantly obtainable of all the drying oils, and on this account its use is very generally understood; secondly, because its cost is generally moderate in comparison with that of other drying oils; and, thirdly, because in our present state of

knowledge the results obtained with it are more uniform than with other oils.

52. Are the same proportions of "Driers" used in all Paints?

No. Some pigments themselves act as "driers"—such in order of drying "strength" are red lead and the other lead oxides, lead carbonate, the iron oxide paints, of which the umbers are the "strongest," the chemical colors beginning with the chrome yellows. Most of the lakes, the blues, zinc-oxides, zinc-lead, sublimed white lead, lithopone have very little drying power—the carbon blacks none. Ordinarily white lead has moderately strong drying properties, varying in this respect according to its chemical constitution.

53. For what purpose are Driers added to Paint or to the Linseed Oil used therein?

For convenience alone. In most circumstances it is desirable that paint shall dry within a reasonable time, to prevent the adhesion of dust and insects, to avoid the danger of soiling of person or clothes, to enable additional coats to be applied.

54. Do Driers improve the wearing qualities of Paints?

By no means. As the final destruction of the paint film is due to oxidation, anything which hastens oxidation shortens the life of the paint.

Therefore, the addition of "driers" and the proportion of drying pigments in a paint should be carefully limited to the practical necessities above indicated.

55. Is China Wood Oil used in Paint Manufacture?

Not so much as in varnish making; but it has some remarkable and valuable properties which may eventually be utilized in paint manufacture.

56. What is Hemp Seed Oil?

The oil expressed from the seeds of the common hemp plant—cannabis sativa. It dries nearly as rapidly as linseed oil, having an iodine number of about 155, as against about 175 for

linseed oil. It is used in Europe as a paint and varnish oil, and was formerly common in "Black Sea oil," the linseed growers mixing hemp seed with the flaxseed exported from that part of Russia. After disappearing from American commerce for a period, it has recently been met with in foreign importations of linseed oil. It is thought to be one of the least objectionable of the cheaper substitutes for linseed oil.

57. What is Fish Oil or Menhaden Oil?

Fish oil is the oil expressed chiefly from the menhaden, a fish which is found in vast numbers along the Atlantic coast. The residues from the presses are used in fertilizers. The special grade known as "winter bleached" is best adapted for paint manufacture. It has an iodine value of about 150 (Mr. H. A. Gardner has found the "Winter Bleached" variety to run as high as 178) and is almost free from odor. A decided "fishy" smell is an indication against the availability of a fish oil for paint.

58. Is Fish or Menhaden Oil admissible in Paint?

"Paint made from fish oil can be applied to hot surfaces and will not blister or peel as readily as that made from linseed oil, and for this purpose—as a smoke-stack paint—it is very desirable."—

"A properly neutralized fish oil prevents the hardening or setting of red lead in the package, and a paste made of this material can be transported a great distance, and will last for many months in a fresh and soft condition."

"Menhaden oil should, of course, be used with a drier, and the best results are obtained with a Tungate [China wood oil] drier."—*Toch.*

59. What are Semi-drying Oils?

Certain vegetable oils which, while possessing some of the characteristics of the drying oils, yet, on account of their constitution, do not completely harden. Those commonly used are corn oil, cottonseed oil and soya bean oil.

60. What are the uses of these Oils in Paint Manufacture?

By special treatment their drying properties may be increased, and in this condition they are sometimes used with linseed oil in connection with strongly-drying pigments. They are also, to some extent, used in the grinding of paste paints, especially red lead and zinc oxide, to prevent hardening in the package; and in the manufacture of putty, a grade of cottonseed oil known as "putty oil" is commonly used to retard hardening and to avoid the excessive ultimate hardness attained when linseed oil alone is employed. The qualities of soya bean oil are discussed separately.

61. What is Soya Bean Oil?

Soya bean oil is an oil derived from several varieties of the soya, soy or soja plant, belonging to the same family as the ordinary pea and bean. While grown in parts of the United States as a forage plant, the source of the seed for the oil used in industry is Manchuria. In its physical characteristics the oil resembles the other semi-drying oils.

62. Is Soya Bean Oil admissible in Paint?

Experiment thus far would indicate that the oil from the soya bean is, perhaps, the least objectionable of the vegetable oils ordinarily used in conjunction with linseed oil; but it is too new to practice to permit of a positive assertion as to its utility or the reverse. Certain investigations would indicate that when properly treated in combination with the drying oils, it may ultimately prove to be a valuable addition to the too meagre list of available paint liquids.

63. Are Petroleum Oils other than Benzine ever used in Paints?

In rare instances, except where they occur as an adulterant of linseed oil sold to painters and consumers. In some special paints for the protection of metal surfaces, heavy petroleum oils are used to a limited extent to retard the hardening of the paint film. As the linseed oil

used in such a combination requires special treatment, these oils should never be used except under expert supervision by the paint manufacturer.

64. What are Volatile Oils or Thinners?

Certain liquids which form a perfect solution with drying oils, and on exposure to the air, evaporate rapidly and more or less completely. They are turpentine, wood turpentine, benzine or naphtha, benzol, alcohol, etc. Of these the first four named are practically the only ones used in paint. Benzol, amyl acetate, methyl alcohol and a few similar products are used in specialties like varnish removers, bronzing liquids, etc.

65. What are the Characteristics of the Volatile Oils?

Of the four used in paint, turpentine is derived by distillation from the sap of pine trees, the residual product being rosin. Wood turpentine is distilled from pine wood waste, pine stumps and roots. Benzine is that distillate from crude petroleum which has a gravity of from 60 to 72 degrees by the Baume hydrometer; the lighter products are gasoline, etc.; the heavier products, fuel oils, burning oils, lubricating oils, etc. The Texas petroleums, having an asphalt base, yield benzines of lower gravity and hence slower evaporation than the oils of the Ohio valley, etc. Turpentine, benzine and benzole have each a characteristic odor. All are solvents of oils, resins, etc. Of the three, turpentine evaporates most slowly, but some of the heavy benzines surpass it in this respect. Turpentine in the retail and jobbing market is frequently adulterated with heavier, non-volatile petroleum oils, but benzine is never so adulterated. Benzine on evaporating leaves no residue and has no effect on the paint film. Turpentine, being a slight oxidizer, is thought to have some drying action and is also believed (because, while the benzine can all be recovered from paint by distillation, the turpentine cannot) to leave something in the paint film. If so, it

would seem that this residue must be of the nature of rosin.

66. What is Wood Turpentine?

Wood turpentine is the volatile distillate from pine wood waste—sawdust, stumps, pine leaves, etc. When properly refined, it is scarcely distinguishable in its properties from gum turpentine, having essentially the same composition.

67. What are the Uses of Wood Turpentine in Paint?

Exactly the same as those of gum turpentine.

68. What is Benzol?

Benzol is that distillate of light oil from coal tar, having a boiling point of 82°C. (180°F.). It is a volatile liquid of characteristic odor, and best known for its great solvent power for gums and resins. The pure benzol is seldom used by the paint trade, but several grades are prepared which are sufficiently refined for commercial use, and could not be distinguished from the purer grade as far as their appearance, odor and action are concerned.

69. What is Toluol?

Toluol (methyl-benzol or toluene) is that distillate of light oil from coal tar having a boiling point of 111° C. (264° F.). It resembles benzol in all its properties, except that it is not so volatile on account of its higher boiling point. It is also produced in commercial grades suitable for the paint trade.

70. What is Solvent Naphtha?

Solvent naphtha is that distillate of light oil from coal tar which boils principally between 130° C. (298° F.) and 160° C. (362° F.). It also corresponds closely in its properties to benzol, and, in fact, it is sometimes called 160° benzol. As its boiling point is higher than that of toluol, it is less volatile than either benzol or toluol, and for this reason is very widely used.

71. What are the Uses of Benzol and similar products in Paint Manufacture?

They are powerful solvents and have been brought before the paint trade largely in paint and varnish removers. They penetrate wood with great ease, and are used widely in oil stains on that account. They are also used frequently for the same purpose as turpentine or petroleum benzine, as a volatile thinner. They have been highly recommended as an additional vehicle in the first coat on resinous or "greasy" woods, such as yellow pine and cypress, to facilitate the penetration of the priming coat. This latter recommendation was first made by Messrs. Louis B. Titsel and John Dewar.

72. What is Creosote Oil?

Creosote oil, strictly speaking, is that oil distilled from coal tar, which is heavier than water. It is frequently called "heavy oil" or "dead oil" of coal tar. Its greatest use in all parts of the world is as a wood preservative. Probably this feature first led to its use in shingle stains, for which purpose it is best known by the paint trade. One of its chief drawbacks at first was the presence of a material which would settle out in cold weather, but more recently grades are available from which this sediment has been removed by chilling and filtering before marketing.

73. For what Purpose are Volatile Oils added to Paint?

For their mechanical effect alone: To facilitate the labor of spreading, to reduce excessive proportions of oil, to hasten the "setting" of the paint, to assist the penetration of the priming coat, to reduce the gloss of under coats and thus improve the adhesion of subsequent coats and to destroy gloss so as to leave a dull finish.

74. Has Turpentine any Advantage over Benzine for these purposes?

Such advantages as it may have are largely dependent on its lower rate of evaporation. This advantage is reduced in the case of the

heavier benzines, and with the rapid destruction of our pine forests the cost of turpentine promises soon to be prohibitive for use in anything except the most expensive varnishes. The only exception to this is in "flat work," for which benzine is not so satisfactory. Wood-turpentine varies greatly in quality, dependent upon the method of manufacture. The better grades which are properly refined are practically identical with sap-turpentine.

75. What are Varnishes?

Varnishes, as used in paint manufacture, are solutions of resins or of fossil gums in drying oils. Their principal application is in enamels and similar specialties.

76. What are the Characteristics of Varnishes.

They yield a firmer, smoother and more lustrous coating than oil, and are capable of being rubbed to a finer finish. Some "Japans," as already stated, have the character of a varnish. Some pigments, of which zinc oxide is a conspicuous example, appear to form a tough elastic combination with the gum resins, entirely different from the compound formed with linseed oil. This property is utilized in the preparation of enamel paints.

77. In view of what has been said, can there be a "Standard" Formula for Paints?

No. As may be inferred, it is possible with different formulas to produce practically the same results; hence any attempt to establish standard formulas merely tends to limit investigation and improvement; to throw the paint industry into the hands of a few producers of raw materials and to stifle competition as well in quality as in price.

78. Is any Standard possible for Paints?

Yes; the standard of quality as determined bv results.

79. What is a Reasonable Standard of Quality for House Paints?

It is based on accumulated experience with the best grades of paints, and indicates the

following as the requirements for a good paint under average conditions:

1. To cover upwards of 300 sq. ft., two coats.

2. To produce a surface that is neither too hard nor too soft.

3. To have an average life of four years.

4. To be durable as to color.

5. To leave a surface suitable for repainting.

80. What is meant by covering upwards of 300 square feet two coats?

These specifications all refer to paints applied to wood. This specification means that each gallon of paint, to be satisfactory, should cover properly with two coats upwards of 300 square feet of surface.

81. What is meant by producing a surface that is neither too hard nor too soft?

A surface that is too hard is subject to abrasion, cracking and chipping off; a surface that is too soft is subject to removal by rubbing or scraping. This characteristic in extreme cases amounts to permanent stickiness; in another sense the phrase includes "chalking," which see.

82. What is meant by having an average life of four years?

That, under average conditions of surface, climate and exposure, repainting shall not become necessary for surface protection more than once every four years. In exceptional or favoring cases this life of a good paint may extend to ten or fifteen years. Except for uncontrollable circumstances it should not fall below three years. Single pigment white paints, except in extraordinary circumstances, will not last over three years. They frequently perish in less than half that time.

83. What is meant by "durable as to color?"

That within the period fixed as the average durability of the paint, there shall be no marked change in the original color of the paint beneath any surface deposit of soot, dust, etc.

Pure white lead, for example, not only darkens on exposure to the gases of the atmosphere, but has a bleaching or discoloring action upon many pigments in daily use, such as Prussian and Ultramarine blues, English and American vermilions and para reds, etc. Even on many of the natural earth pigments it has a bleaching action. By proper combination with other pigments these defects are eliminated, while the durability of the coating is enhanced.

84. What is meant by "leaving a surface suitable for repainting?"

That when repainting becomes necessary the remainder of the old paint will present a practically unbroken surface and permit of firm adhesion of the new coating.

85. How does Paint disappear from a surface?

It may chalk, peel, scale, flake or wear away.

86. What is chalking?

Chalking is that quality (most characteristic of the white lead and lithopone, which some paints have of disintegrating, falling into powder and dusting or washing from the surface, irrespective of normal wear and tear. It is most probably due to progressive chemical action between oil and pigment in the presence of oxygen, carbonic acid gas and moisture. The paint on a "chalking" surface will rub off on the clothing. Such paint has been included in a foregoing definition as "too soft."

87. What is peeling?

Peeling indicates an imperfect attachment of the paint film to the surface. The term sufficiently describes the action. Any paint may peel if applied to a damp, greasy or resinous surface. Peeling may also be caused by interior artificial heat, driving moisture outwards under the paint film; by capillary moisture rising into wood in contact with the earth, etc. Pure linseed oil paints are most liable to this defect.

88. What are scaling and flaking?

The premature detachment of paint in small scales or larger flakes. A brittle paint, in

the circumstances where a more elastic paint would peel, will scale or flake, according to its degree of brittleness.

89. What is meant by wearing away?

The normal wear of paint is both a chemical and a mechanical process. The action of atmospheric oxygen on linseed oil, as already stated, is progressive from a tough elastic substance to a pulverulent mass. A coating of linseed oil alone disappears in this way. The addition of an inert, opaque pigment, obstructing the penetration of air and light, limits this action to the surface of the paint film. As the surface thus disintegrates, it is slowly and uniformly washed or worn away, exposing continually a fresh surface to the atmospheric attack, until the entire film is thus worn away. Thus, while this normal wear is dependent upon external causes, "chalking" is due to a destructive chemical action between the components of the paint itself.

90. What is the most Desirable Mode of Disappearance?

Naturally by normal wear, and it is one of the chief objects of the well-informed paint chemist and paint manufacturer so to compound and prepare his products that they shall not chalk, scale, flake nor peel,, but wear away normally from the surface.

91. How is this accomplished?

By maintaining a due chemical balance between pigments, oils, driers and other ingredients of the paint, as well as by a careful selection of the single ingredients themselves, —care for example, that the iron oxides contain no free sulphuric acid; that the linseed oil is properly ripened and settled and the free fatty acid content not abnormal; that proper allowances be made in composition for umbers with a high manganese content; that the chemical activity of the white lead selected be duly compensated for by some other ingredient, etc.

92. In view of the foregoing facts, is it possible, or if possible, advisable, to prepare all tints with a white base of fixed composition?

By no means. It will be understood, from what has been stated, that practically every tint or shade, if the ideal practice were followed, would require a separate formula and special treatment. But confining himself within rational practical limits, the enlightened paint manufacturer divides his tinting colors into groups with common characteristics and varies his white base and his formulas according to the group. Thus, the well-informed manufacturer may combine the vermilions, blues, para reds, etc., with zinc oxide, zinc lead, lithopone, the inert pigments, but he will be very chary of combining any of them with a base containing carbonate of lead.

93. What is the Cause of Blistering of Paint?

Heat vaporizing underlying moisture. Only new paint is subject to this evil, unless the heat be excessive, and one paint appears to be as much subject to it as another. Excess of volatile oil prevents it. Incompletely dried lumber would seem to be the chief cause. It may be partially due to a chemical action of light and heat on the oil, segregating glycerine under the blisters and partially to the expansion of the water in moist spots under the paint. The blisters often disappear in a short time, but the paint is detached from the surface and will scale away when the paint becomes brittle. They are merely a detached covering, not an adherent coating of paint.

94. What is "Alligatoring?"

An incomplete form of peeling, where the paint cracks into large segments, one end of the segment loosening and curling back from the surface, while the other end remains firmly attached, the surface remotely resembling the back of an alligator. When the alligatoring is fine and incomplete it is usually termed "checking."

95. What is the Cause of "Alligatoring?"

Heavy coats of paint applied to unseasoned wood will alligator, especially if the paint be slow drying, tough and inelastic. Rosin drier in zinc paints is said by Toch to be the chief cause of the form known as "checking."

96. What is the Remedy?

Scrape or burn the old paint off and repaint with thinner coats.

97. How may chalking, peeling, flaking, alligatoring, etc., be avoided?

By the selection of a properly prepared paint and its proper application to a surface in fit condition for painting.

98. What is a properly prepared paint?

A paint in which the ingredients are selected with due regard to their physical and chemical characteristics and thoroughly amalgamated into a homogeneous mixture, proper grinding of the pigments being also essential.

99. What is meant by the proper application of paint to a surface in fit condition for painting?

The "proper application of paint" has reference to the consistency of the paint when applied, to the method of application, and to the time allowed to elapse between coats. The fitness of the surface for painting refers to its cleanliness, the nature as well as the condition of the wood, and the state of the weather at the time of painting.

100. How should the consistency of the paint be varied for different surfaces?

The painter should understand these requirements. The priming coat, being the one on which the adhesion of the entire paint film depends, should be most carefully considered. It should be sufficiently liquid to penetrate every pore and irregularity of the surface, carrying with it particles of the pigment; but this fluidity must not be obtained at the cost of the future strength of the dried film. For the priming coat it is customary to add a quantity of oil

and some turpentine or benzine, or, in the case of cypress, yellow pine and resinous woods in general, some form of benzol. It is easy to overdo both. Only enough of the volatile thinner should be used to avoid a high gloss, to which subsequent coats will not readily adhere. Hard, unabsorbent woods require a thicker priming coat than spongy woods, such as poplar, soft pine, etc. Resinous woods, like yellow pine, again, require special treatment—a preliminary varnishing of knots and resinous spots with shellac, and subsequent priming with a fluid priming coat containing a benzol product.

The second coat, which in many instances is also (improperly) the finishing coat, should be tempered accordingly. If there are to be three coats (as there should be), the paint should be slightly reduced with turpentine or benzine, so as to promote amalgamation with the priming coat, and to reduce the surface gloss. If it is to be the finishing coat, prepared paint of the average consistency can be used without reduction, but a very little turpentine is sometimes desirable to assist penetration and adhesion.

The third or finishing coat should usually be employed as it comes from the can. In the case of all coats, thorough, hard brushing is essential, and a round brush is always preferable to a flat brush. The failure of paint is frequently due to insufficient "elbow grease" with the brush.

Every coat of paint should be completely dry throughout before the next coat is applied; but it is a mistake to allow a priming coat to "weather" and become weakened before painting is continued.

Too much drier or japan, or cheap rosin japans are at the bottom of many paint failures. The manufacturer of a scientifically prepared paint will introduce the proper kind and quantity of driers into his formula, and none should be added in use.

101. How is a fit condition of surface obtained?

First, by delaying the application of the priming coat until the wood is thoroughly seasoned,

unless seasoning has been properly attended to in the lumber; secondly, by seeing that the plaster on the inside of the building is completely dry before painting is begun on the outside. A new house should have been heated some weeks before it is painted. In an old house, leaking spouts, etc., should be repaired and the adjacent wood allowed to dry thoroughly before repainting. Thirdly, by avoiding the application of paint in moist weather or when the atmospheric moisture is high. Fourthly, by selecting a dry, mild season, as late spring or early fall, rather than a cold or hot season, as winter or mid-summer, for the work. Fifthly, by seeing that sappy or resinous spots in new lumber are properly treated before painting. Sixthly, by due care on old work that all loose paint and dust are removed by scraping, sandpapering, wire-brushing, dusting or, if necessary, burning, before new paint is applied.

As a rule, it should always be remembered that two thin coats thoroughly brushed out, are better in most cases than one thick coat, and that repainting should never be delayed until the under coats begin to loosen seriously.

102. Can the Ordinary Property Owner Obtain Satisfactory Results with Prepared Paint by applying it himself?

Only when conditions are favorable. In any case he should study carefully the directions on the can, and unless they are found to apply to his particular job, should consult either the manufacturer or a practical painter for fulller advice.

103. Will a Chemical Analysis Determine the Quality of a Paint?

No. To the expert paint chemist it will indicate whether the paint is scientifically compounded or not; but of the method of preparation, which is quite as important as composition, it will tell nothing, and of the nature and quality of the vehicles very little. Only a thorough and exhaustive physical examination will indicate the real value of the paint.

104. What is "Wall Finish"?

"Wall finish" is the title usually applied to a type of paint for application to interior wall surfaces, drying to a flat or lustreless finish and capable of being washed without injury. It sometimes contains some ingredient intended to neutralize the free lime in plaster or cement. The white pigment base is usually lithopone, zinc oxide or sublimed lead in combination with some reinforcing pigment, and the vehicles are specially prepared oil or varnish compounds which dry "flat" and become waterproof on drying.

105. What are the Merits of these Finishes?

They are infinitely more sanitary than wall paper, and being very durable, are in the end far more economical. They replace with a material designed on correct principles the old flat finishes produced by painters by washing the oil "binder" out of paste paints with turpentine, which is both wasteful and unscientific, in that the paint is thus deprived of its essential "binding" ingredients.

106. Why is Paint preferable to Paper for Interior Walls?

Briefly, because it can be washed. A pamphlet recently issued by the Institute of Industrial Research, at Washington, clearly shows that paint exposed under the same conditions, side by side with wall paper, remains comparatively free from bacteria, while the wall paper swarms with them. Bacteria are the cause of infectious diseases, such as diphtheria, scarlet fever, typhoid fever, grippe and common colds.

107. What is Cement Paint?

A type of paint specially designed for the preservation and embellishment of cement, concrete or plaster surfaces.

108. What are Its Characteristics?

In contradistinction to ordinary oil paints, it adheres permanently to the surface and retains its original color.

109. How may Cement or Plaster Surfaces be prepared for the use of ordinary Oil Paint?

Mr. Charles Macnichol, of Washington, D. C., recommends treatment with a saturated solution of zinc sulphate. The chemical reactions involved transform the free lime in the cement to calcium sulphate (gypsum) and the zinc sulphate into zinc hydroxide, both of which products remain in the surface-layer of the cement or plaster and retard absorption. Better results can usually be obtained by using a paint designed for the purpose.

110. What is the Electrolytic Theory of Corrosion?

Research has shown that corrosion of steel surfaces is largely due to a difference of electric potential between adjacent points. This difference of potential may be due to uneven distribution of components (steel contains small percentages of various substances besides iron) or to difference of tension, etc. The rule is that where such differences of potential exist, a current will pass from the higher to the lower whenever an electrolyte (a liquid capable of conducting the current) connects them. Ordinary moisture is sufficient for the purpose. At the same time, the substance at the higher potential will pass into solution, carrying an electrical charge, and if means of neutralizing this charge be at hand, the process will continue indefinitely. In the case of steel, oxidation neutralizes the electric charge and enables electrolytic corrosion to proceed. The details of this theory have been formulated by Drs. Cushman and Walker; and more recently have been confirmed experimentally by others, notably Mr. James Cobb, of the British Iron and Steel Institute.

111. What is meant by Inhibition?

In connection with the electrolytic theory, it was found that certain substances act as retarders of local corrosion, and experiments, duplicated by a number of trained observers, indicated that certain pigments in common use possess this power. Chief of these are the chromates—zinc

chrome, chrome yellows (lead chromes), scarlet chrome, the compound chromates (lead and zinc, zinc and barium, etc.,) and zinc oxide. Other pigments were found apparently to stimulate or facilitate corrosion. The entire matter is now under practical test on a large scale, and the results thus far, in a general way, appear to give ample confirmation of the correctness of the theory.

112. What is an Inhibitive Paint?

A paint so constituted that it will resist or inhibit local electrolysis in the presence of an electrolyte. Such paints usually contain a small percentage of zinc chrome or other chromate, zinc chrome being the most common, though the other chromates, when alkaline or neutral in reaction, are believed to be equally efficient and zinc oxide nearly so. Other paints of this type are rendered inhibitive by a special treatment of ordinary basic pigments, in which the surfaces of the pigment particles are "chromatized."

113. Will the Blow-pipe determine whether White Lead is good or bad?

No. It will tell whether or not the material is a pure lead compound, but it will reveal nothing regarding its qualities as paint. The soluble salts of lead, such as the acetate or the nitrate, will yield metallic lead with the blowpipe more readily than will the carbonate, but when found in white lead they are very detrimental. On the other hand, the more stable white compounds of lead, such as the oxy-sulphate, though they may be pure lead compounds, will not reduce before the blow-pipe without the use of a flux, except in the hands of a skilled operator.

114. In View of all the Foregoing, what is the True Test of Paint Value?

Service. The conditions, physical, chemical and technical governing the behavior of paint in any given case are so numerous and so obscure that it is hopeless for anyone but an expert to attempt to comprehend them. House

paint is designed to cover a wide range of conditions and the better grades of prepared paints meet the average conditions with remarkable success. As between the many competing products, naturally, it is to the record of success rather than the composition of the paints that the consumer must look for enlightenment. There is always a reason—usually there are many reasons—why a certain paint under certaln conditions meets or fails to meet the requirements; but these reasons are usually obscure and technical and quite beyond the range of common knowledge. It may be taken as axiomatic that no paint obtains permanent popularity except on the basis of substantial merit. Success begets success, and nothing could be more conducive to increased sale of a given paint in any locality than the ocular demonstration of its value on painted buildings. It is this practical demonstration of superior convenience, economy and durability which has caused the consumption of prepared paint to expand from the humble beginnings of the industry in the late fifties, to its vast proportions of the present day.

SUMMARY.

From the foregoing it will be seen that paint manufacture is a progressive industry, dependent for success upon the knowledge and skill at the command of the manufacturer. The constant addition of new pigments and other materials to the list of available products and the keen competition between manufacturers insure progress. Sixty or seventy years ago there was but one white pigment generally available as a paint base. This was the carbonate of lead. The fact that its use precluded the use of many beautiful tinting colors, its well recognized sanitary inconveniences and its deficient durability, led not only to improvements in its handling and application, but also to its very general extension with inert pigments and to a diligent search for other white bases. This research has given us oxide of zinc, leaded zinc, sublimed white lead, zinc-lead-white and lithopone—all white pigments of great impor-

tance to the paint-consuming public. The field of paint production has thus been vastly extended, and the manufacturer has it within his power to vary his paint base as the conditions of use and the chemical nature of his tinting colors require.

The history of oxide of zinc in this connection is familiar. Since the middle of the last century its consumption has grown from nothing to something like 80,000 tons annually in the U. S. alone. The history of sublimed lead is another familiar instance. The important and rapidly growing use of this pigment as one of the raw materials depended upon by the paint manufacturer for prepared paint is an excellent illustration of the advantages to the public at large resulting from the development of the paint industry, for the reason that sublimed white lead would probably not be in use to-day at all as a pigment, if its use had depended upon its utilization in hand-mixed paints; while, on the other hand, the paint manufacturer has been able to give the public the very real values and advantages of this pigment in the can of paint.

White lead,—that is the ordinary hydro-carbonate—owing to the long-continued use of the term to describe all kinds of white paints in paste form, has acquired an undue importance in the popular mind. While an extremely useful and valuable pigment, it is only one of many, and in a large proportion of the dark shades commonly used neither it nor any of the other white bases (excepting the inert pigments) has any place whatever. Furthermore, as has been shown it is absolutely misplaced and injurious in many of the popular tints produced from chemical colors,—the greens, blues, yellows, pinks, lavenders, salmons, delicate grays, etc., to cite only a few examples. In these cases and many others the tint can be safely produced only with zinc oxide, sublimed white lead, zinc-lead or some similarly inactive white base. Even when white lead can be safely used, either by itself or in combination with the "limited palette" recommended by lead manufacturers, expert testimony strongly inclines to the opinion

that its value for painting requirements is considerably enhanced by the addition of other white pigments and inert materials.

In the present state of our knowledge it is absolutely impossible to assert with authority that any given formula is "the best." We can say, however, that many formulas in common use are excellent and that it is surprising that from so great a variety we should obtain results so nearly identical. As before stated, the "best paint" is that which produces the most uniformly satisfactory results—for paint is bought to produce results, not to demonstrate technical theories. The widely celebrated paint test fences, at the end of four or five years, are reported by the official committees to have demonstrated conclusively one fact, which is formulated as follows: "A combination of two or more of the prime white pigments, with or without the addition of a moderate percentage of reinforcing pigments, is superior to any one of these pigments used alone."

In conclusion, let us boldly and confidently assert that prepared paints are the sum of paint progress; that the hand of progress moves forward and not backward on the dial; and that the American people having once realized the economy, convenience and common sense of the sealed can with its completed product, will not voluntarily return to the paint pot and paddle.

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